

Coordination in a Supply Chain

LEARNING OBJECTIVES

After reading this chapter, you will be able to

1. Describe supply chain coordination and the bullwhip effect, and their impact on supply chain performance.
2. Identify obstacles to coordination in a supply chain.
3. Discuss managerial levers that help achieve coordination in a supply chain.
4. Understand the different forms of collaborative planning, forecasting, and replenishment that are possible in a supply chain.

In this chapter, we extend the ideas from Chapter 9 and focus on improving coordination across the supply chain. We discuss how lack of coordination leads to a degradation of responsiveness and an increase in cost within a supply chain. We describe various obstacles that lead to this lack of coordination and exacerbate variability through the supply chain. We then identify appropriate managerial levers that can help overcome the obstacles and achieve coordination. In particular, we discuss how collaboration can improve supply chain performance.

10.1 LACK OF SUPPLY CHAIN COORDINATION AND THE BULLWHIP EFFECT

Supply chain coordination improves if all stages of the chain take actions that are aligned and increase total supply chain surplus. Supply chain coordination requires each stage of the supply chain to share information and take into account the impact its actions have on other stages.

A lack of coordination occurs either because different stages of the supply chain have local objectives that conflict or because information moving between stages is delayed and distorted. Different stages of a supply chain may have conflicting objectives if each stage tries to maximize its own profits, resulting in actions that often diminish total supply chain profits (see Chapters 11, 13, and 15). Today, supply chains consist of stages with different owners. For example, Ford Motor Company has thousands of suppliers, from Goodyear to Motorola, and each of these suppliers has

many suppliers in turn. Not only does each stage focus on its own objectives, but information is also often distorted as it moves across the supply chain because complete information is not shared between stages. This distortion is exaggerated by the fact that supply chains today produce a large variety of products. Ford produces different models, with several options for each model. The increased variety makes it difficult for Ford to coordinate information exchange with thousands of suppliers and dealers. The fundamental challenge today is for supply chains to achieve coordination in spite of multiple ownership and increased product variety.

One outcome of the lack of supply chain coordination is the *bullwhip effect*, in which fluctuations in orders increase as they move up the supply chain from retailers to wholesalers to manufacturers to suppliers, as shown in Figure 10-1. The bullwhip effect distorts demand information within the supply chain, with each stage having a different estimate of what demand looks like.

Procter & Gamble (P&G) has observed the bullwhip effect in the supply chain for Pampers diapers (Lee, Padmanabhan, and Whang, 1997). The company found that raw material orders from P&G to its suppliers fluctuated significantly over time. Farther down the chain, when sales at retail stores were studied, the fluctuations, though present, were small. It is reasonable to assume that the consumers of diapers (babies) at the last stage of the supply chain used them at a steady rate. Although consumption of the end product was stable, orders for raw material were highly variable, increasing costs and making it difficult to match supply and demand.

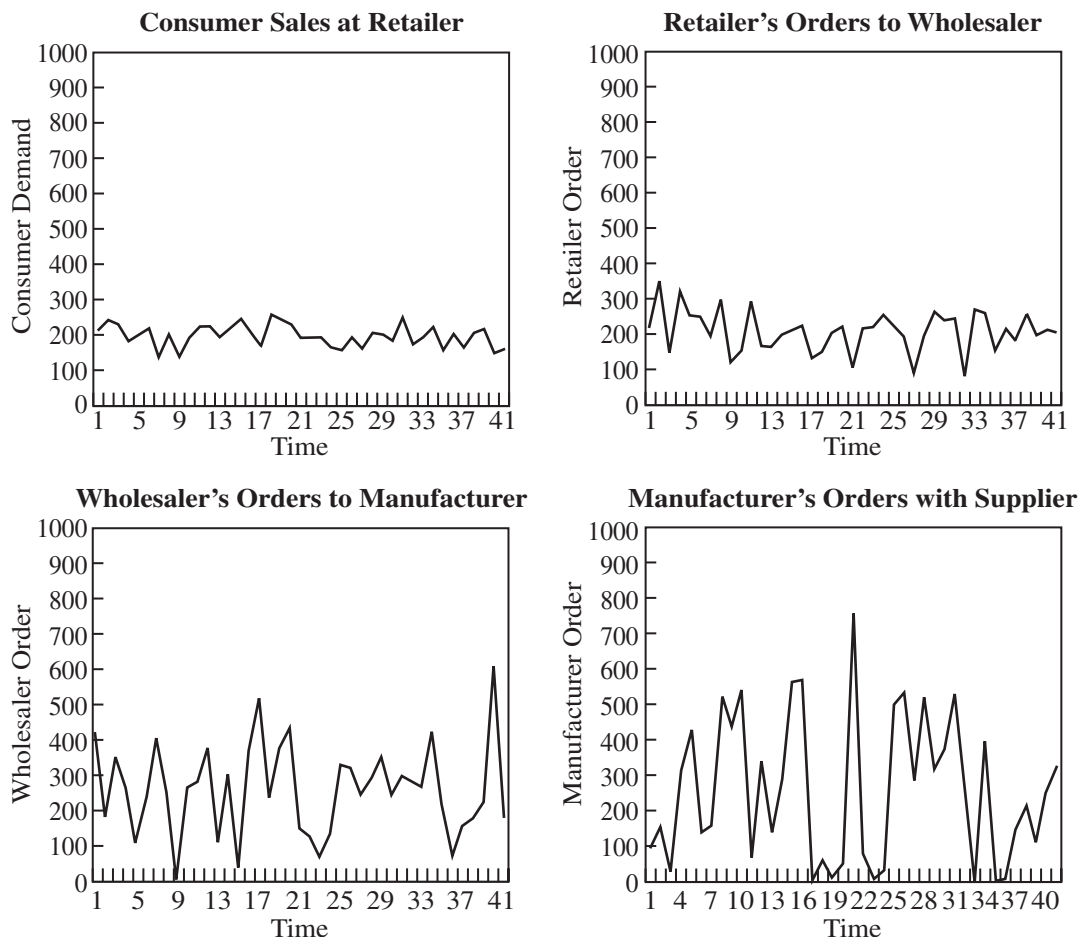


FIGURE 10-1 Demand Fluctuations at Different Stages of a Supply Chain

Hewlett-Packard (HP) also found that the fluctuation in orders increased significantly as they moved from the resellers up the supply chain to the printer division to the integrated circuit division (*ibid.*). Once again, although product demand showed some variability, orders placed with the integrated circuit division were much more variable. This made it difficult for HP to fill orders on time and increased the cost of doing so.

Studies of the apparel and grocery industries have shown a similar phenomenon: The fluctuation in orders increases as one moves upstream in the supply chain from retail to manufacturing. Barilla, an Italian manufacturer of pasta, observed that weekly orders placed by a local distribution center fluctuated by up to a factor of 70 in the course of the year, whereas weekly sales at the distribution center (representing orders placed by supermarkets) fluctuated by a factor of less than three (Hammond, 1994). Barilla was thus facing demand from the distribution center that was much more variable than customer demand. This led to increased inventories, poorer product availability, and a drop in profits.

A similar phenomenon, over a longer time frame, has been observed in several industries that are quite prone to “boom and bust” cycles. A good example is the production of memory chips for personal computers. Between 1985 and 1998, at least two cycles occurred during which prices of memory chips fluctuated by a factor of more than three. These large fluctuations in price were driven by either large shortages or surpluses in capacity. The shortages were exacerbated by panic buying and overordering that was followed by a sudden drop in demand.

In the next section, we consider how lack of coordination affects supply chain performance.

10.2 THE EFFECT ON PERFORMANCE OF LACK OF COORDINATION

The lack of coordination in a supply chain increases variability and hurts the supply chain surplus. We discuss the impact of the bullwhip effect on various costs in the P&G diaper supply chain.

Manufacturing Cost

The lack of coordination increases manufacturing cost in the supply chain. As a result of the bullwhip effect, P&G and its suppliers must satisfy a stream of orders that is much more variable than customer demand. P&G can respond to the increased variability by either building excess capacity or holding excess inventory (see Chapter 8), both of which increase the manufacturing cost per unit produced.

Inventory Cost

The lack of coordination increases inventory cost in the supply chain. To handle the increased variability in demand, P&G must carry a higher level of inventory than would be required if the supply chain were coordinated. As a result, inventory costs in the supply chain increase. The high levels of inventory also increase the warehousing space required and thus the warehousing cost incurred.

Replenishment Lead Time

Lack of coordination increases replenishment lead times in the supply chain. The increased variability as a result of the bullwhip effect makes scheduling at P&G and supplier plants much more difficult than when demand is level. There are times when the available capacity and inventory cannot supply the orders coming in. This results in higher replenishment lead times.

Transportation Cost

The lack of coordination increases transportation cost in the supply chain. The transportation requirements over time at P&G and its suppliers are correlated with the orders being filled. As a result of the bullwhip effect, transportation requirements fluctuate significantly over time. This

raises transportation cost because surplus transportation capacity needs to be maintained to cover high-demand periods.

Labor Cost for Shipping and Receiving

The lack of coordination increases labor costs associated with shipping and receiving in the supply chain. Labor requirements for shipping at P&G and its suppliers fluctuate with orders. A similar fluctuation occurs for the labor requirements for receiving at distributors and retailers. The various stages have the option of carrying excess labor capacity or varying labor capacity in response to the fluctuation in orders. Either option increases total labor cost.

Level of Product Availability

Lack of coordination hurts the level of product availability and results in more stockouts in the supply chain. The large fluctuations in orders make it harder for P&G to supply all distributor and retailer orders on time. This increases the likelihood that retailers will run out of stock, resulting in lost sales for the supply chain.

Relationships Across the Supply Chain

Lack of coordination has a negative effect on performance at every stage and thus hurts the relationships among different stages of the supply chain. There is a tendency to assign blame to other stages of the supply chain because each stage thinks it is doing the best it can. The lack of coordination thus leads to a loss of trust among different stages of the supply chain and makes any potential coordination efforts more difficult.

From the earlier discussion, it follows that lack of coordination has a significant negative impact on the supply chain's performance by increasing cost and decreasing responsiveness. The impact of the lack of coordination on different performance measures is summarized in Table 10-1.

In the next section, we discuss various obstacles to achieving coordination in the supply chain.

Key Point

The lack of coordination hurts both responsiveness and cost in a supply chain by making it more expensive to provide a given level of product availability.

TABLE 10-1 Impact of the Lack of Coordination on Supply Chain Performance	
Performance Measure	Impact of the Lack of Coordination
Manufacturing cost	Increases
Inventory cost	Increases
Replenishment lead time	Increases
Transportation cost	Increases
Shipping and receiving cost	Increases
Level of product availability	Decreases
Profitability	Decreases

10.3 OBSTACLES TO COORDINATION IN A SUPPLY CHAIN

Any factor that leads to either local optimization by different stages of the supply chain or an increase in information delay, distortion, and variability within the supply chain is an obstacle to coordination. If managers in a supply chain are able to identify the key obstacles, they can then take suitable actions to help achieve coordination. We divide the major obstacles into five categories:

- Incentive obstacles
- Information-processing obstacles
- Operational obstacles
- Pricing obstacles
- Behavioral obstacles

Incentive Obstacles

Incentive obstacles occur in situations when incentives offered to different stages or participants in a supply chain lead to actions that increase variability and reduce total supply chain profits.

LOCAL OPTIMIZATION WITHIN FUNCTIONS OR STAGES OF A SUPPLY CHAIN Incentives that focus only on the local impact of an action result in decisions that do not maximize total supply chain surplus. For example, if the compensation of a transportation manager at a firm is linked to the average transportation cost per unit, the manager is likely to take actions that lower transportation costs even if they increase inventory costs or hurt customer service. It is natural for any participant in the supply chain to take actions that optimize performance measures along which they are evaluated. For example, managers at a retailer such as Kmart make all their purchasing and inventory decisions to maximize Kmart profits, not total supply chain profits. Buying decisions based on maximizing profits at a single stage of the supply chain lead to ordering policies that do not maximize supply chain profits (see Chapters 11, 13, and 15).

SALES FORCE INCENTIVES Improperly structured sales force incentives are a significant obstacle to coordination in a supply chain. In many firms, sales force incentives are based on exceeding sales thresholds during an evaluation period of a month or quarter. The sales typically measured by a manufacturer are the quantity sold to distributors or retailers (sell-in), not the quantity sold to final customers (sell-through). Measuring performance based on sell-in is often justified on the grounds that the manufacturer's sales force does not control sell-through. For example, Barilla offered its sales force incentives based on the quantity sold to distributors during a four- to six-week promotion period. To maximize their bonuses, the Barilla sales force urged distributors to buy more pasta toward the end of the evaluation period, even if distributors were not selling as much to retailers. The sales force offered discounts they controlled to spur end-of-period sales. This increased variability in the order pattern, with a jump in orders toward the end of the evaluation period followed by few orders at the beginning of the next evaluation period. Order sizes from distributors to Barilla fluctuated by a factor of up to 70 from one week to the next. A sales force incentive based on sell-in thus results in order variability being larger than customer demand variability because the sales force tends to push product toward the end of the incentive period.

Information-Processing Obstacles

Information-processing obstacles occur when demand information is distorted as it moves between different stages of the supply chain, leading to increased variability in orders within the supply chain.

FORECASTING BASED ON ORDERS AND NOT CUSTOMER DEMAND When stages within a supply chain make forecasts that are based on orders they receive, any variability in customer

demand is magnified as orders move up the supply chain to manufacturers and suppliers. In supply chains where the fundamental means of communication among different stages are the orders that are placed, information is distorted as it moves up the supply chain (see Chen, Drezner, Ryan, and Simchi-Levi [2000] for a good quantitative analysis). Each stage views its primary role within the supply chain as one of filling orders placed by its downstream partner. Thus, each stage views its demand as the stream of orders received and produces a forecast based on this information.

In such a scenario, a small change in customer demand becomes magnified as it moves up the supply chain in the form of customer orders. Consider the impact of a random increase in customer demand at a retailer. The retailer may interpret part of this random increase as a growth trend. This interpretation will lead the retailer to order more than the observed increase in demand because the retailer expects growth to continue into the future and thus orders to cover for future anticipated growth. The increase in the order placed with the wholesaler is thus larger than the observed increase in demand at the retailer. Part of the increase is a one-time increase. The wholesaler, however, has no way to interpret the order increase correctly. The wholesaler simply observes a jump in the order size and infers a growth trend. The growth trend inferred by the wholesaler will be larger than that inferred by the retailer (recall that the retailer increased the order size to account for future growth). The wholesaler will thus place an even larger order with the manufacturer. As we go farther up the supply chain, the order size is magnified.

Now assume that periods of random increase are followed by periods of random decrease in demand. Using the same forecasting logic as earlier, the retailer will now anticipate a declining trend and reduce order size. This reduction will also become magnified as we move up the supply chain.

LACK OF INFORMATION SHARING The lack of information sharing between stages of the supply chain magnifies the information distortion. A retailer such as Walmart may increase the size of a particular order because of a planned promotion. If the manufacturer is not aware of the planned promotion, it may interpret the larger order as a permanent increase in demand and place orders with suppliers accordingly. The manufacturer and suppliers thus have much inventory right after Walmart finishes its promotion. Given the excess inventory, as future Walmart orders return to normal, manufacturer orders will be smaller than before. The lack of information sharing between the retailer and manufacturer thus leads to a large fluctuation in manufacturer orders.

Operational Obstacles

Operational obstacles occur when actions taken in the course of placing and filling orders lead to an increase in variability.

ORDERING IN LARGE LOTS When a firm places orders in lot sizes that are much larger than those in which demand arises, variability of orders is magnified up the supply chain. Firms may order in large lots because a significant fixed cost is associated with placing, receiving, or transporting an order (see Chapter 11). Large lots may also occur if the supplier offers quantity discounts based on lot size (see Chapter 11). Figure 10-2 shows both the demand and the order stream for a firm that places an order every five weeks. Observe that the order stream is far more erratic than the demand stream.

Because orders are batched and placed every five weeks, the order stream has four weeks without orders followed by a large order that equals five weeks of demand. A manufacturer supplying several retailers that batch their orders faces an order stream that is much more variable than the demand the retailers experience. If the manufacturer batches its orders to suppliers, the effect is further magnified. In many instances, there are certain focal-point periods, such as the first or the last week of a month, when a majority of the orders arrive. This synchronization of orders further exacerbates the impact of batching.

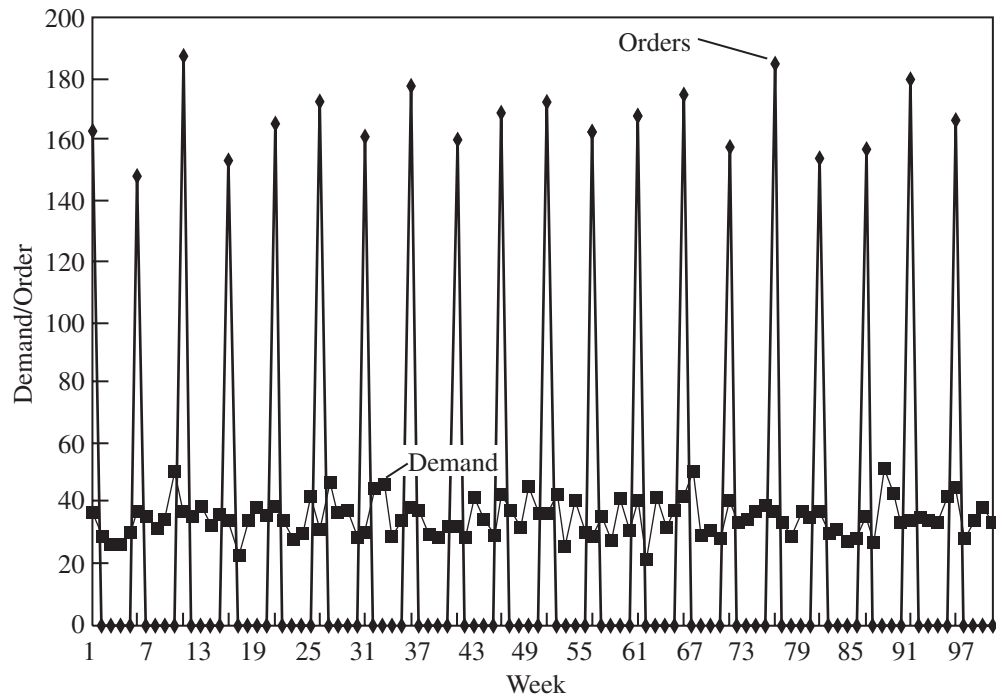


FIGURE 10-2 Demand and Order Stream with Orders Every Five Weeks

LARGE REPLENISHMENT LEAD TIMES Information distortion is magnified if replenishment lead times between stages are long. Consider a situation in which a retailer has misinterpreted a random increase in demand as a growth trend. If the retailer faces a lead time of two weeks, it will incorporate the anticipated growth over two weeks when placing the order. In contrast, if the retailer faces a lead time of two months, it will incorporate into its order the anticipated growth over two months (which will be much larger). The same applies when a random decrease in demand is interpreted as a declining trend.

RATIONING AND SHORTAGE GAMING Rationing schemes that allocate limited production in proportion to the orders placed by retailers lead to a magnification of information distortion. This can occur when a high-demand product is in short supply. In such a situation, manufacturers come up with a variety of mechanisms to ration the scarce supply of product among various distributors or retailers. One commonly used rationing scheme is to allocate the available supply of product based on orders placed. Under this rationing scheme, if the supply available is 75 percent of the total orders received, each retailer receives 75 percent of its order.

This rationing scheme results in a game in which retailers try to increase the size of their orders to increase the amount supplied to them. A retailer needing 75 units orders 100 units in the hope of getting 75. The net impact of this rationing scheme is to artificially inflate orders for the product. In addition, a retailer ordering based on what it expects to sell gets less and as a result loses sales, whereas a retailer that inflates its order is rewarded.

If the manufacturer is using orders to forecast future demand, it will interpret the increase in orders as an increase in demand, even though customer demand is unchanged. The manufacturer may respond by building enough capacity to be able to fill all orders received. Once sufficient capacity becomes available, orders return to their normal level because they were inflated in response to the rationing scheme. The manufacturer is now left with a surplus of product and capacity. These boom-and-bust cycles thus tend to alternate. This phenomenon is fairly common in the electronics industry, in which alternating periods of component shortages followed by a component surplus are often observed.

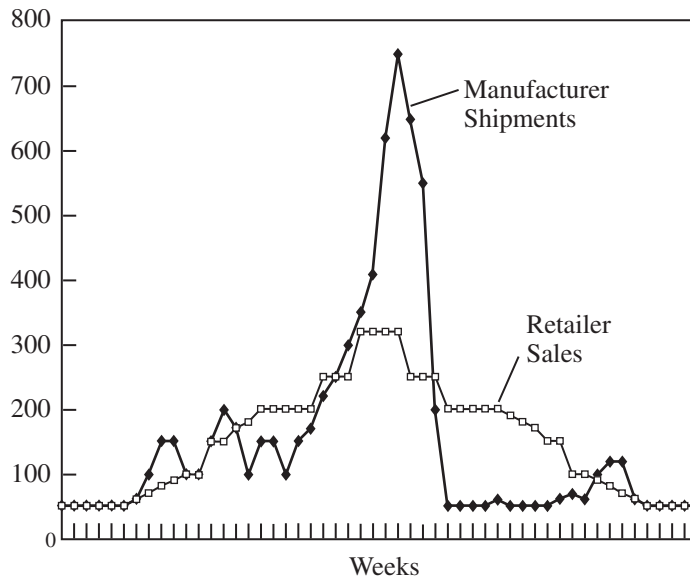


FIGURE 10-3 Retailer Sales and Manufacturer Shipments of Soup
Source: Adapted from Marshall L. Fisher, "What Is the Right Supply Chain for Your Product?" by *Harvard Business Review* (March–April 1997): 83–93. Copyright © 1997 by the Harvard Business School Publishing Corporation; all rights reserved. Reprinted by permission of *Harvard Business Review*.

Pricing Obstacles

Pricing obstacles arise when the pricing policies for a product lead to an increase in variability of orders placed.

LOT-SIZE-BASED QUANTITY DISCOUNTS Lot-size-based quantity discounts increase the lot size of orders placed within the supply chain (see Chapter 11) because lower prices are offered for larger lots. As discussed earlier, the resulting large lots magnify the bullwhip effect within the supply chain.

PRICE FLUCTUATIONS Trade promotions and other short-term discounts offered by a manufacturer result in forward buying, by which a wholesaler or retailer purchases large lots during the discounting period to cover demand during future periods. Forward buying results in large orders during the promotion period followed by very small orders after that (see Chapter 11), as shown in Figure 10-3 for chicken noodle soup.

Observe that the shipments during the peak period are higher than the sales during the peak period because of a promotion offered. The peak shipment period is followed by a period of low shipments from the manufacturer, indicating significant forward buying by distributors. The promotion thus results in a variability in manufacturer shipments that is significantly higher than the variability in retailer sales.

Behavioral Obstacles

Behavioral obstacles are problems in learning within organizations that contribute to information distortion. These problems are often related to the supply chain structure and the communications among different stages. Some of the behavioral obstacles are as follows:

1. Each stage of the supply chain views its actions locally and is unable to see the impact of its actions on other stages.

2. Different stages of the supply chain react to the current local situation rather than trying to identify the root causes.
3. Based on local analysis, different stages of the supply chain blame one another for the fluctuations, with successive stages in the supply chain becoming enemies rather than partners.
4. No stage of the supply chain learns from its actions over time because the most significant consequences of its actions occur elsewhere. The result is a vicious cycle in which actions taken by one stage create the very problems that the stage blames on others.
5. A lack of trust among supply chain partners causes them to be opportunistic at the expense of overall supply chain performance. The lack of trust also results in significant duplication of effort. More important, information available at different stages either is not shared or is ignored because it is not trusted.

10.4 MANAGERIAL LEVERS TO ACHIEVE COORDINATION

Having identified obstacles to coordination, we now focus on actions a manager can take to help overcome the obstacles and achieve coordination in the supply chain. The following managerial actions increase total supply chain profits and moderate information distortion:

- Aligning goals and incentives
- Improving information visibility and accuracy
- Improving operational performance
- Designing pricing strategies to stabilize orders
- Building strategic partnerships and trust

Aligning Goals and Incentives

Managers can improve coordination within the supply chain by aligning goals and incentives so every participant in supply chain activities works to maximize total supply chain profits.

ALIGNING GOALS ACROSS THE SUPPLY CHAIN Coordination requires every stage of the supply chain to focus on the supply chain surplus or the total size of the pie rather than just its individual share. A key to coordination is coming up with mechanisms that allow the creation of a win-win scenario in which the supply chain surplus grows along with the profits for all supply chain stages. An example of such a mechanism occurs when Walmart pays Hewlett-Packard (HP) for each printer sold and gives HP the power to make replenishment decisions while limiting the amount of printer inventory that can be held at a store. This setup improves coordination because both parties gain if the supply of printers at a store matches demand.

ALIGNING INCENTIVES ACROSS FUNCTIONS One key to coordinated decisions within a firm is to ensure that the objective any function uses to evaluate a decision is aligned with the firm's overall objective. All facility, transportation, and inventory decisions should be evaluated based on their effect on profitability or total costs, not functional costs. This helps prevent situations such as a transportation manager making decisions that lower transportation cost but increase overall supply chain costs (see Chapter 14).

PRICING FOR COORDINATION In many instances, suitable pricing schemes can help coordinate the supply chain. A manufacturer can use lot-size-based quantity discounts to achieve coordination for commodity products if the manufacturer has large fixed costs associated with each lot (see Chapter 11 for a detailed discussion). For products for which a firm has market power, a manufacturer can use two-part tariffs and volume discounts to help achieve coordination (see Chapter 11 for a detailed discussion). Given demand uncertainty, manufacturers can use buy-back, revenue-sharing, and quantity flexibility contracts to spur retailers to provide levels of

product availability that maximize total supply chain profits (see Chapter 15 for a detailed discussion). Buyback contracts have been used in the publishing industry to increase total supply chain profits. Quantity flexibility contracts have helped Benetton increase supply chain profits.

ALTERING SALES FORCE INCENTIVES FROM SELL-IN TO SELL-THROUGH Any change that reduces the incentive for a salesperson to push product to the retailer reduces the bullwhip effect. Manufacturers should link incentives for the sales staff to sell-through by the retailer rather than sell-in to the retailer. This action eliminates any motivation the sales staff may have to encourage forward buying. Elimination of forward buying helps reduce fluctuations in the order stream. If sales force incentives are based on sales over a rolling horizon, the incentive to push product is further reduced. This helps reduce forward buying and the resulting fluctuation in orders.

Improving Information Visibility and Accuracy

Managers can achieve coordination by improving the visibility and accuracy of information available to different stages in the supply chain.

SHARING CUSTOMER DEMAND DATA Sharing customer demand data across the supply chain can help reduce the bullwhip effect. A primary cause for information distortion is the fact that each stage of the supply chain uses orders to forecast future demand. Given that orders received by different stages vary, forecasts at different stages also vary. In reality, the only demand that the supply chain needs to satisfy is that from the final customer. If retailers share demand data with other supply chain stages, all stages can forecast future demand based on customer demand. Sharing of demand data helps reduce information distortion because all stages now respond to the same change in customer demand. Observe that sharing aggregate demand data is sufficient to dampen information distortion. It is not necessary to share detailed point-of-sale (POS) data. Use of appropriate information systems facilitates the sharing of such data.

Walmart has routinely shared its POS data with its suppliers. Dell shares demand data as well as current inventory positions of components with many of its suppliers via the Internet, thereby helping avoid unnecessary fluctuations in supply and orders placed. P&G has convinced many retailers to share demand data. P&G, in turn, shares the data with its suppliers, improving coordination in the supply chain.

IMPLEMENTING COLLABORATIVE FORECASTING AND PLANNING Once customer demand data are shared, different stages of the supply chain must forecast and plan jointly if complete coordination is to be achieved. Without collaborative planning, sharing of demand data does not guarantee coordination. A retailer may have observed large demand in the month of January because it ran a promotion. If no promotion is planned in the upcoming January, the retailer's forecast will differ from the manufacturer's forecast even if both have past POS data. The manufacturer must be aware of the retailer's promotion plans to achieve coordination. The key is to ensure that the entire supply chain is operating with a common forecast. To facilitate this type of coordination in the supply chain environment, the Voluntary Interindustry Commerce Standards (VICS) Association set up a Collaborative Planning, Forecasting, and Replenishment (CPFR) Committee that identified best practices and design guidelines for collaborative planning and forecasting. These practices are detailed later in the chapter.

DESIGNING SINGLE-STAGE CONTROL OF REPLENISHMENT Designing a supply chain in which a single stage controls replenishment decisions for the entire supply chain can help diminish information distortion. As we mentioned earlier, a key cause of information distortion is that each stage of the supply chain uses orders from the previous stage as its historical demand. As a result, each stage views its role as one of replenishing orders placed by the next stage. In reality, the key replenishment is at the retailer, because that is where the final customer purchases. When

a single stage controls replenishment decisions for the entire chain, the problem of multiple forecasts is eliminated and coordination within the supply chain follows.

Several industry practices, such as continuous replenishment programs (CRPs) and vendor-managed inventories (VMIs) detailed later in the chapter, provide a single-point control over replenishment. Walmart typically assigns one of its suppliers as a leader for each major product category to manage store-level replenishment. This gives suppliers visibility into sales and a single decision maker for replenishment decisions.

Key Point

Demand planning at each stage in a supply chain based on the stream of orders received from its downstream stage results in a magnification of fluctuation in orders as one moves up the supply chain from the retailer to the manufacturer. It is better for the entire supply chain to forecast based on end customer demand.

Improving Operational Performance

Managers can help dampen information distortion by improving operational performance and designing appropriate product rationing schemes in case of shortages.

REDUCING REPLENISHMENT LEAD TIME By reducing the replenishment lead time, managers can decrease the uncertainty of demand during the lead time (see Chapter 12). A reduction in lead time is especially beneficial for seasonal items because it allows for multiple orders to be placed with a significant increase in the accuracy of the forecast (see Chapter 13). If lead times are short enough, replenishment can be scheduled to actual consumption, thus eliminating the need for a forecast.

Managers can take a variety of actions at different stages of the supply chain to help reduce replenishment lead times. Ordering electronically, either online or through electronic data interchange (EDI), can significantly cut the lead time associated with order placement and information transfer. If every stage shares its long-term plans with suppliers, potential orders can be scheduled into production well in advance, with the precise quantity being determined closer to actual production. This reduces the scheduling time, which is often the largest component of lead time. At manufacturing plants, increased flexibility and cellular manufacturing can be used to achieve a significant reduction in lead times. A dampening of information distortion further reduces lead times because of stabilized demand and, as a result, improved scheduling. This is particularly true when manufacturing produces a large variety of products. Advance shipping notices (ASNs) can be used to reduce the lead time as well as efforts associated with receiving. Cross-docking can be used to reduce the lead time associated with moving the product between stages in the supply chain. Walmart has used many of these approaches to significantly reduce lead time within its supply chain.

REDUCING LOT SIZES Managers can reduce information distortion by implementing operational improvements that reduce lot sizes. A reduction of lot sizes decreases the amount of fluctuation that can accumulate between any pair of stages of a supply chain, thus decreasing distortion. To reduce lot sizes, managers must take actions that help reduce the fixed costs associated with ordering, transporting, and receiving each lot (see Chapter 11). Walmart and Seven-Eleven Japan have been very successful at reducing replenishment lot sizes by aggregating deliveries across many products and suppliers.

Computer-assisted ordering (CAO) refers to the substitution through technology of the functions of a retail order clerk through the use of computers that integrate information about

product sales, market factors affecting demand, inventory levels, product receipts, and desired service levels. CAO and EDI help reduce the fixed costs associated with placing each order.

In some cases, managers can simplify ordering by eliminating the use of purchase orders. In the auto industry, some suppliers are paid based on the number of cars produced, eliminating the need for individual purchase orders. This eliminates the order-processing cost associated with each replenishment order. Information systems also facilitate the settlement of financial transactions, eliminating the cost associated with individual purchase orders.

The large gap in the prices of truckload (TL) and less-than-truckload (LTL) shipping encourages shipment in TL quantities. In fact, with the efforts to reduce order-processing costs, transportation costs are now the major barrier to smaller lots in most supply chains. Managers can reduce lot sizes without increasing transportation costs by filling a truck using smaller lots from a variety of products (see Chapter 11). P&G, for example, requires all orders from retailers to be a full TL. The TL, however, may be built from any combination of products. A retailer can thus order small lots of each product as long as a sufficiently large variety of products are included on each truck. Seven-Eleven Japan has used this strategy with combined trucks, in which the separation is by the temperature at which the truck is maintained. All products to be shipped at a particular temperature are on the same truck. This has allowed Seven-Eleven Japan to reduce the number of trucks sent to retail outlets while keeping product variety high. Some firms in the grocery industry use trucks with different compartments, each at a different temperature and carrying a variety of products, to help reduce lot sizes.

Managers can also reduce lot sizes by using milk runs that combine shipments for several retailers on a single truck, as discussed in Chapter 14. In many cases, third-party transporters combine shipments to competing retail outlets on a single truck. This reduces the fixed transportation cost per retailer and allows each retailer to order in smaller lots. In Japan, Toyota uses a single truck from a supplier to supply multiple assembly plants, which enables managers to reduce the lot size received by any one plant. Managers can also reduce lot sizes by combining shipments from multiple suppliers on a single truck. In the United States, Toyota uses this approach to reduce the lot size it receives from any one supplier.

As smaller lots are ordered and delivered, both the pressure on and the cost of receiving can grow significantly. Thus, managers must implement technologies that simplify the receiving process and reduce the cost associated with receiving. For example, ASNs identify shipment content, count, and time of delivery electronically and help reduce unloading time and increase cross-dock efficiency. ASNs can be used to update inventory records electronically, thus reducing the cost of receiving. Bar coding of pallets and the use of radio frequency identification (RFID) can further simplify receiving.

Another simple way to minimize the impact of batching is to break any synchronization of orders. Frequently, customers that order once a week tend to do so on either a Monday or Friday. Customers that order once a month tend to do so either at the beginning or the end of the month. In such situations, it is better to distribute customers ordering once a week evenly across all days of the week, and customers ordering once a month across all days of the month. In fact, regular ordering days may be scheduled in advance for each customer to level out the order stream arriving at the manufacturer.

RATIONING BASED ON PAST SALES AND SHARING INFORMATION TO LIMIT GAMING To diminish information distortion, managers can design rationing schemes that discourage retailers from artificially inflating their orders in case of a shortage. One approach, referred to as *turn-and-earn*, is to allocate the available supply based on past retailer sales rather than current retailer orders. Tying allocation to past sales removes any incentive a retailer may have to inflate orders. In fact, during low-demand periods, the turn-and-earn approach pushes retailers to try to sell more to increase the allocation they receive during periods of shortage. Several firms, including General Motors, have historically used the turn-and-earn mechanism to ration available product in case of a shortage. Others, such as HP, have historically allocated based on retailer orders but are now switching to using past sales.

Other firms have tried to share information across the supply chain to minimize shortage situations. Firms such as Sport Obermeyer offer incentives to their large customers to preorder at least a part of their annual order. This information allows Sport Obermeyer to improve the accuracy of its own forecast and allocate production capacity accordingly. Once capacity has been allocated appropriately across different products, it is less likely that shortage situations will arise, thus dampening the inflation of orders. The availability of flexible capacity can also help in this regard, because flexible capacity can easily be shifted from a product whose demand is lower than expected to one whose demand is higher than expected.

Designing Pricing Strategies to Stabilize Orders

Managers can reduce information distortion by devising pricing strategies that encourage retailers to order in smaller lots and reduce forward buying.

MOVING FROM LOT-SIZE-BASED TO VOLUME-BASED QUANTITY DISCOUNTS As a result of lot-size-based quantity discounts, retailers increase their lot size to take full advantage of the discount. Offering volume-based quantity discounts eliminates the incentive to increase the size of a single lot because volume-based discounts consider the total purchases during a specified period (say, a year) rather than purchases in a single lot (see Chapter 11). Volume-based quantity discounts result in smaller lot sizes, thus reducing order variability in the supply chain. Volume-based discounts with a fixed end date at which discounts will be evaluated may lead to large lots close to the end date. Offering the discounts over a rolling time horizon helps dampen this effect.

STABILIZING PRICING Managers can dampen the bullwhip effect by eliminating promotions and using everyday low pricing (EDLP). The elimination of promotions removes forward buying by retailers and results in orders that match customer demand. P&G, Campbell Soup, and several other manufacturers have implemented EDLP to dampen the bullwhip effect.

Managers can place limits on the quantity that may be purchased during a promotion to decrease forward buying. This limit should be retailer specific and linked to historical sales by the retailer. Another approach is to tie the promotion dollars paid to the retailer to the amount of sell-through rather than the amount purchased by the retailer. As a result, retailers obtain no benefit from forward buying and purchase more only if they can sell more. Promotions based on sell-through significantly reduce information distortion.

Building Strategic Partnerships and Trust

Managers find it easier to use the levers discussed earlier to achieve coordination if trust and strategic partnerships are built within the supply chain. Sharing of accurate information that is trusted by every stage results in a better matching of supply and demand throughout the supply chain. A better relationship also tends to lower the transaction cost between supply chain stages. For example, a supplier can eliminate its forecasting effort if it trusts orders and forecast information received from the retailer. Similarly, the retailer can lessen the receiving effort by decreasing counting and inspections if it trusts the supplier's quality and delivery. In general, stages in a supply chain can eliminate duplicated effort on the basis of improved trust and a better relationship. This lowering of transaction cost, along with accurate shared information, helps improve coordination. Walmart and P&G have tried to build a strategic partnership that will better coordinate their actions and be mutually beneficial.

Research by Kumar (1996) showed that the more retailers trusted their suppliers, the less likely they were to develop alternate sources while significantly increasing sales of their products. In general, a high level of trust allows a supply chain to become more responsive at lower cost. Actions such as information sharing, changing of incentives, operational improvements, and stabilization of pricing typically help improve the level of trust. Growing the level of cooperation and trust within a supply chain requires a clear identification of roles and decision rights for all parties, effective contracts, and good conflict resolution mechanisms.

10.5 CONTINUOUS REPLENISHMENT AND VENDOR-MANAGED INVENTORIES

Information distortion can be dampened by practices that assign replenishment responsibility across the supply chain to a single entity. Replenishment decisions made by a single entity ensure visibility and a common forecast that drives orders across the supply chain. Two common industry practices that assign a single point of responsibility are continuous replenishment programs and vendor-managed inventories.

In continuous replenishment programs (CRPs), the wholesaler or manufacturer replenishes a retailer regularly based on POS data. CRP may be managed by the supplier, distributor, or a third party. In most instances, CRP systems are driven by actual withdrawals of inventory from retailer warehouses rather than POS data at the store level. Tying CRP systems to warehouse withdrawals is easier to implement, and retailers are often more comfortable sharing data at this level. IT systems that are linked across the supply chain provide a good information infrastructure on which a CRP may be based. In CRP, inventory at the retailer is owned by the retailer.

With vendor-managed inventory (VMI), the manufacturer or supplier is responsible for all decisions regarding product inventories at the retailer. As a result, the control of the replenishment decision moves to the manufacturer instead of the retailer. In many instances of VMI, the inventory is owned by the supplier until it is sold by the retailer. VMI requires the retailer to share demand information with the manufacturer to allow it to make inventory replenishment decisions. This helps improve manufacturer forecasts and better match manufacturer production with customer demand. VMI can allow a manufacturer to increase its profits—as well as profits for the entire supply chain—if both retailer and manufacturer margins are considered when making inventory decisions.

VMI has been implemented with significant success by, among others, Kmart (with about 50 suppliers) and Fred Meyer. Kmart saw inventory turns on seasonal items increase from 3 to between 9 and 11, and for nonseasonal items from 12 to 15 to 17 to 20. Fred Meyer saw inventories drop by 30 to 40 percent while fill rates increased to 98 percent. Other firms with successful implementations include Campbell Soup, Frito-Lay, and P&G.

One drawback of VMI arises because retailers often sell products from competing manufacturers that are substitutes in the customer's mind. For example, a customer may substitute detergent manufactured by P&G by detergent manufactured by Unilever. If the retailer has a VMI agreement with both manufacturers, each manufacturer will ignore the impact of substitution when making inventory decisions. As a result, inventories at the retailer will be higher than optimal. In such a setting, the retailer may be better positioned to decide on the replenishment policy. Another possibility is for the retailer to define a category leader from among the suppliers and have the category leader manage replenishment decisions for all suppliers in the category. Walmart follows such a practice and assigns a category leader for most of its products. Walmart sets the targeted level of product availability across all products and the category leader designs replenishment policies that achieve these levels. This ensures that the category leader is not favoring any one supplier's product over another. For example, HP was Walmart's category leader for printers and managed all printer replenishment.

10.6 COLLABORATIVE PLANNING, FORECASTING, AND REPLENISHMENT

The VICS Association has defined CPFR as “a business practice that combines the intelligence of multiple partners in the planning and fulfillment of customer demand.” In this section, we describe CPFR and some successful implementations. It is important to understand that successful CPFR can be built only on a foundation in which the two parties have synchronized their data and established standards for exchanging information.

Sellers and buyers in a supply chain may collaborate along any or all of the following four supply chain activities:

- 1. Strategy and planning.** The partners determine the scope of the collaboration and assign roles, responsibilities, and clear checkpoints. In a joint business plan, they then identify significant events such as promotions, new product introductions, store openings/closings, and changes in inventory policy that affect demand and supply.
- 2. Demand and supply management.** A collaborative sales forecast projects the partners' best estimate of consumer demand at the point of sale. This is then converted to a collaborative order plan that determines future orders and delivery requirements based on sales forecasts, inventory positions, and replenishment lead times.
- 3. Execution.** As forecasts become firm, they are converted to actual orders. The fulfillment of these orders then involves production, shipping, receiving, and stocking of products.
- 4. Analysis.** The key analysis tasks focus on identifying exceptions and evaluating metrics that are used to assess performance or identify trends.

A fundamental aspect of successful collaboration is the identification and resolution of exceptions. Exceptions refer to a gap between forecasts made by the two sides or some other performance metric that is falling or is likely to fall outside acceptable bounds. These metrics may include inventories that exceed targets or product availability that falls below targets. For successful CPFR, it is important to have a process in place that allows the two parties to resolve exceptions. Detailed processes for identifying and resolving exceptions are discussed in the VICS CPFR Voluntary Guidelines version 2.0 (2002).

One successful CPFR implementation has involved Henkel, a German detergent manufacturer, and Eroski, a Spanish food retailer. Prior to CPFR, Eroski saw frequent stockouts of Henkel products, especially during promotions. At the inception of CPFR in December 1999, 70 percent of the sales forecasts had an average error of more than 50 percent, and only 5 percent of the forecasts had errors less than 20 percent. Within four months of the CPFR implementation, however, 70 percent of the sales forecasts had errors less than 20 percent and only 5 percent had errors of more than 50 percent. CPFR resulted in a customer service level of 98 percent and an average inventory of only five days. This was accomplished despite 15 to 20 products being promoted every month.

Another successful implementation involved Johnson & Johnson and Superdrug, a chain in the United Kingdom. Over the three-month trial period beginning April 2000, Superdrug saw inventory levels at its DCs drop by 13 percent, while product availability at its DCs increased by 1.6 percent. As reported by Steerman (2003), Sears also saw significant benefits from its CPFR initiative with Michelin in 2001. In-stock levels at Sears improved by 4.3 percent, DCs-to-stores fill rate improved by 10.7 percent, and overall inventory levels fell by 25 percent.

VICS has identified the four scenarios in Table 10-2 as the most common areas in which large-scale CPFR deployments have taken place between a retailer and a manufacturer. Next, we describe each of the four scenarios.

TABLE 10-2 Four Common CPFR Scenarios		
CPFR Scenario	Where Applied in Supply Chain	Industries Where Applied
Retail event collaboration	Highly promoted channels or categories	All industries other than those that practice EDLP
DC replenishment collaboration	Retail DC or distributor DC	Drugstores, hardware, grocery
Store replenishment collaboration	Direct store delivery or retail DC-to-store delivery	Mass merchants, club stores
Collaborative assortment planning	Apparel and seasonal goods	Department stores, specialty retail

Retail Event Collaboration

In many retail environments, such as supermarkets, promotions and other retail events have a significant impact on demand. Stockouts, excess inventory, and unplanned logistics costs during these events affect financial performance for both the retailer and the manufacturer. In such a setting, collaboration between retailers and suppliers to plan, forecast, and replenish promotions is effective.

Retail event collaboration requires the two parties to identify brands and specific SKUs that are included in the collaboration. Details of the event—such as timing, duration, price point, advertising, and display tactics—are shared. It is important for the retailer to update this information as changes occur. Event-specific forecasts are then created and shared. These forecasts are then converted to planned orders and deliveries. As the event unfolds, sales are monitored to identify any changes or exceptions, which are resolved through an iterative process between the two parties.

P&G has implemented some form of retail event collaboration with a variety of partners, including Walmart.

DC Replenishment Collaboration

DC replenishment collaboration is perhaps the most common form of collaboration observed in practice and also the simplest to implement. In this scenario, the two trading partners collaborate on forecasting DC withdrawals or anticipated demand from the DC to the manufacturer. These forecasts are converted to a stream of orders from the DC to the manufacturer that are committed or locked over a specified time horizon. This information allows the manufacturer to include anticipated orders in future production plans and build the committed orders on demand. The result is a reduction in production cost at the manufacturer and a reduction of inventory and stockouts at the retailer.

DC replenishment collaboration is relatively easy to implement because it requires collaboration on aggregate data and does not require sharing of detailed POS data. As a result, it is often the best scenario with which to start collaboration. Over time, this form of collaboration can be extended to include all storage points in the supply chain, from retail shelves to raw material warehouses. According to Hammond (1994), Barilla implemented this form of collaboration with its distributors.

Store Replenishment Collaboration

In store replenishment collaboration, trading partners collaborate on store-level POS forecasts. These forecasts are then converted to a series of store-level orders, with orders committed over a specified time horizon. This form of collaboration is much harder to implement than a DC-level collaboration, especially if stores are small; it is easier for large stores such as Costco and Home Depot. The benefits of store-level collaboration include greater visibility of sales for the manufacturer, improved replenishment accuracy, improved product availability, and reduced inventories. Smith (2013) discusses how store level collaboration allowed suppliers to Canadian retailer West Marine, Inc. to improve “on-time shipments from a dismal 30 percent to over 90 percent.” This allowed West Marine to maintain product availability as high as 98 percent.

Collaborative Assortment Planning

Fashion apparel and other seasonal goods follow a seasonal pattern of demand. Thus, collaborative planning in these categories has a horizon of a single season and is performed at seasonal intervals. Given the seasonal nature, forecasts rely less on historical data and more on collaborative interpretation of industry trends, macroeconomic factors, and customer tastes. In this form of collaboration, the trading partners develop an assortment plan jointly. The output is a planned purchase order at the style/color/size level. The planned order is shared electronically in advance

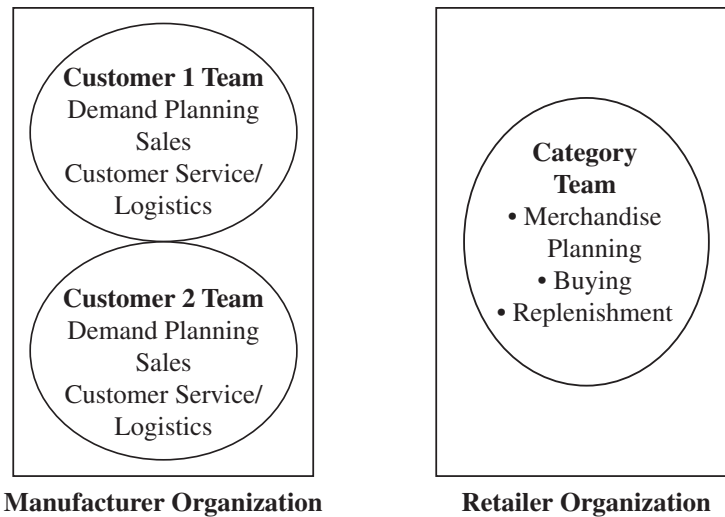


FIGURE 10-4 Collaborative Organizational Structure
 Source: Adapted from Voluntary Interindustry Commerce Standards, *CPFR: An Overview*, 2004.

of a show, at which sample products are viewed and final merchandising decisions are made. The planned orders help the manufacturer purchase long-lead-time raw materials and plan capacity. This form of collaboration is most useful if capacity is flexible enough to accommodate a variety of product mix and raw materials have some commonality across end products.

Organizational and Technology Requirements for Successful CPFR

A successful CPFR implementation requires changes in the organizational structure and, to be scalable, requires the implementation of appropriate technology. Effective collaboration requires manufacturers to set up cross-functional, customer-specific teams that include sales, demand planning, and logistics, at least for large customers. Such a focus has become feasible with the consolidation in retailing. For smaller customers, such teams can be focused by geography or sales channel. Retailers should also attempt to organize merchandise planning, buying, and replenishment into teams around suppliers. This can be difficult, given the large number of suppliers that consolidated retailers have. They can then organize the teams by categories that include multiple suppliers. For retailers that have multiple levels of inventory, such as DCs and retail stores, it is important to combine the replenishment teams at the two levels. Without collaborative inventory management at the two levels, duplication of inventories is common. The proposed organizational structure is illustrated in Figure 10-4.

The CPFR process is not dependent on technology but requires technology to be scalable. CPFR technologies have been developed to facilitate sharing of forecasts and historical information, evaluating exception conditions, and enabling revisions. These solutions must be integrated with enterprise systems that record all supply chain transactions.

Risks and Hurdles for a CPFR Implementation

It is important to realize that there are risks and hurdles for a successful CPFR implementation. Given the large-scale sharing of information, there is a risk of information misuse. Often one or both of the CPFR partners have relationships with the partner's competitors. Another risk is that if one of the partners changes its scale or technology, the other partner will be forced to follow suit or lose the collaborative relationship. Finally, the implementation of CPFR and the resolution of exceptions require close interactions between two entities whose cultures may be very

different. The inability to foster a collaborative culture across the partner organizations can be a major hurdle for the success of CPFR. One of the biggest hurdles to success is often that partners attempt store-level collaboration, which requires a higher organizational and technology investment. It is often best to start with an event- or DC-level collaboration, which is more focused and easier to collaborate on. Another major hurdle for successful CPFR is that demand information shared with partners is often not used within the organization in an integrated manner. It is important to have integrated demand, supply, logistics, and corporate planning within the organization to maximize the benefits of a CPFR effort with a partner.

10.7 ACHIEVING COORDINATION IN PRACTICE

1. Quantify the bullwhip effect. Companies often have no idea that the bullwhip effect plays a significant role in their supply chain. Managers should start by comparing the variability in the orders they receive from their customers with the variability in orders they place with their suppliers. This helps a firm quantify its own contribution to the bullwhip effect. Once its contribution is visible, it becomes easier for a firm to accept the fact that all stages in the supply chain contribute to the bullwhip effect, leading to a significant loss in profits. In the absence of this concrete information, companies try to react better to the variability rather than eliminate the variability itself. This leads companies to invest significant amounts in inventory management and scheduling systems, only to see little improvement in performance or profits. Evidence of the size of the bullwhip effect is effective in getting different stages of the supply chain to focus on efforts to achieve coordination and eliminate the variability created within the supply chain.

2. Get top management commitment for coordination. More than any other aspect of supply chain management, coordination can succeed only with top management's commitment. Coordination requires managers at all stages of the supply chain to subordinate their local interests to the greater interest of the firm, and even of the supply chain. Coordination often requires the resolution of trade-offs in a way that requires many functions in the supply chain to change their traditional practices. These changes often run counter to approaches that were put in place when each function focused only on its local objective. Such changes within a supply chain cannot be implemented without strong top management commitment. Top management commitment was a key factor in helping Walmart and P&G set up collaborative forecasting and replenishment teams.

3. Devote resources to coordination. Coordination cannot be achieved without all parties involved devoting significant managerial resources to this effort. Companies often do not devote resources to coordination because they either assume that lack of coordination is something they have to live with or they hope that coordination will occur on its own. The problem with this approach is that it leaves all managers involved with only the separate areas that they control, while no one is responsible for highlighting the impact one manager's actions have on other parts of the supply chain. One of the best ways to solve coordination problems is through teams made up of members from different companies throughout the supply chain. These teams should be made responsible for coordination and given the power to implement the changes required. Setting up a coordination team is fruitless unless the team has the power to act, because the team will run into conflict with functional managers who are currently maximizing local objectives. Coordination teams can be effective only once a sufficient level of trust builds between members from different firms. If they are used properly, coordination teams can provide significant benefit, as has happened with the collaborative forecasting and replenishment teams set up by Walmart and P&G.

4. Focus on communication with other stages. Good communication with other stages of a supply chain often creates situations that highlight the value of coordination for both sides. Companies often do not communicate with other stages of the supply chain and are unwilling to share information. However, often all companies in the supply chain are frustrated by the lack of coordination and would be happy to share information if it helped the supply chain operate in a more effective manner. Regular communication among the parties involved facilitates change in

such a setting. For instance, a major PC company had been ordering its microprocessors in batches of several weeks of production. It was trying to move to a build-to-order environment in which it would place microprocessor orders on a daily basis. The PC company assumed that the microprocessor supplier would be reluctant to go along with this approach. However, once communication was opened up with the supplier, the opposite turned out to be true. The supplier also wanted to reduce lot sizes and increase the frequency of orders. It had just assumed that the PC manufacturer wanted large lots and thus never requested a change. Regular communication helps different stages of the supply chain share their goals and identify common goals and mutually beneficial actions that improve coordination.

5. Try to achieve coordination in the entire supply chain network. The full benefit of coordination is achieved only when the entire supply chain network is coordinated. It is not enough for two stages in a supply chain to coordinate. The most powerful party in a supply chain should make an effort to achieve coordination in the entire network. Toyota has been very effective in achieving knowledge sharing and coordination in its entire network.

6. Use technology to improve connectivity in the supply chain. The Internet and a variety of software systems can be used to increase the visibility of information throughout the supply chain. Until now, most IT implementations have achieved visibility of information only within a firm. Visibility across the supply chain still requires additional effort in most cases. From the discussion in this chapter, it should be clear that the major benefits of IT systems can be realized only if the systems help increase visibility across the supply chain and facilitate coordination. If firms are to realize the full benefit of the huge investments they make in current IT systems, particularly ERP systems, it is crucial that they make the extra effort required to use these systems to facilitate collaborative forecasting and planning across the supply chain. The Internet should be used to share information and increase connectivity in the supply chain.

7. Share the benefits of coordination equitably. The greatest hurdle to coordination in the supply chain is the belief on the part of any stage that the benefits of coordination are not being shared equitably. Managers from the stronger party in the supply chain relationship must be sensitive to this fact and ensure that all parties perceive that the way benefits are shared is fair.

10.8 SUMMARY OF LEARNING OBJECTIVES

1. Describe supply chain coordination and the bullwhip effect, and their impact on supply chain performance. Supply chain coordination requires all stages to take actions that maximize total supply chain profits. A lack of coordination results if different stages focus on optimizing their local objectives or if information is distorted as it moves across the supply chain. The phenomenon that fluctuation in orders increases as one moves up the supply chain from retailers to wholesalers to manufacturers to suppliers is referred to as the bullwhip effect. This effect results in an increase in all costs in the supply chain and a decrease in customer service levels. The bullwhip effect moves all parties in the supply chain away from the efficient frontier and results in a decrease of both customer satisfaction and profitability within the supply chain.

2. Identify obstacles to coordination in a supply chain. A key obstacle to coordination in the supply chain is misaligned incentives that result in different stages optimizing local objectives instead of total supply chain profits. Other obstacles include lack of information sharing, operational inefficiencies leading to large replenishment lead times and large lots, sales force incentives that encourage forward buying, rationing schemes that encourage inflation of orders, promotions that encourage forward buying, and a lack of trust that makes any effort toward coordination difficult.

3. Discuss managerial levers that help achieve coordination in a supply chain. Managers can help achieve coordination in the supply chain by aligning goals and incentives across different functions and stages of the supply chain. Other actions that managers can take to achieve coordination include sharing of sales information and collaborative forecasting and planning, implementation of single-point control of replenishment, improving operations to reduce

lead times and lot sizes, EDLP and other strategies that limit forward buying, and the building of trust and strategic partnerships within the supply chain.

4. Understand the different forms of collaborative planning, forecasting, and replenishment that are possible in a supply chain. Partners may set CPFR relationships to collaborate on store events, DC replenishment, store replenishment, or assortment planning. DC replenishment collaboration is often the easiest to implement because it requires aggregate-level data. Store replenishment collaboration requires a higher level of investment in technology and data sharing to be successful.

Discussion Questions

1. What characterizes supply chains that could be affected significantly by the bullwhip effect? How can the bullwhip effect be reduced?
2. What is the impact of lack of coordination on the performance of a supply chain?
3. In what way can improper incentives lead to a lack of coordination in a supply chain? What countermeasures can be used to offset this effect?
4. What problems result if each stage of a supply chain views its demand as the orders placed by the downstream stage? How should firms within a supply chain communicate to facilitate coordination?
5. What factors lead to a batching of orders within a supply chain? How does this affect coordination? What actions can minimize large batches and improve coordination?
6. What measures can a company employ to raise operational performance when information is distorted within the supply chain?
7. Compare and contrast continuous replenishment programs (CRPs) and vendor-managed inventory (VMI).
8. What are the different CPFR scenarios and how do they benefit supply chain partners?

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